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Transforming the enterprise of aqcuiring public sector complex systems

Rouse, William

Monterey, California. Naval Postgraduate School

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TRANSFORMING THE ENTERPRISE OF AQCUIRING PUBLIC SECTOR COMPLEX SYSTEMS

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by

William Rouse, Michael Pennock and Diane L. Kollar

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Transforming the Enterprise of Acquiring Public Sector Complex Systems

Presenter: William Rouse, Tennenbaum Institute, Georgia Institute of Technology

Presenter: Michael Pennock, Tennenbaum Institute, Georgia Institute of Technology

Presenter: Diane L. Kollar, Tennenbaum Institute, Georgia Institute of Technology

William B. Rouse, Michael J. Pennock and Diane L. Kollar
Tennenbaum Institute
Georgia Institute of Technology
(www.ti.gatech.edu)

Abstract

The acquisition of public sector complex systems is time consuming, very expensive, and rife with uncertainties. The enterprise associated with acquisition is an excellent candidate for transformation—fundamental change to achieve substantially higher levels of value. This paper argues that choosing among alternative transformation initiatives should be based on an enterprise-wide perspective as well as an economic valuation of the alternative investments. An options-based methodology for assessing economic value is presented and illustrated.

Introduction

Enterprises that acquire public sector complex systems are facing serious cost challenges. Costs of military platforms (e.g., ships), space platforms (e.g., space stations) and transportation systems (e.g., airports) have increased enormously in the past few decades, far beyond inflation during this period. Consequently, the public sector enterprises that acquire these systems anticipate buying fewer systems. This tends to sacrifice needed capabilities as well as exacerbate the cost challenges.

This paper addresses the question of where resources should be invested to transform the overall acquisition enterprise and ameliorate this problem. The model of the enterprise adopted includes political entities (e.g., Congress), government agencies (e.g., the military services), contracting companies (e.g., defense contractors), workforce organizations (e.g., unions), development and construction facilities (e.g., ship yards), and suppliers to facilities. This model is illustrated in the context of military shipbuilding.

A portfolio management approach is outlined that enables understanding and balancing the returns and risks associated with alternative investments, as well as highlighting investments that dominate alternatives in terms of both returns and risks. Investments considered include rationalizing of authorization and acquisition processes, streamlining of acquisition policies and practices, accelerating bid and proposal processes, modifying work processes and procedures, redesigning incentives and reward systems and, of course, investments in improving the system itself.

BACKGROUND

To an extent, we are addressing the question of the economic value of reforming acquisition. To place our approach in context, it is valuable to understand the effects of previous reform efforts and the current state of research on the acquisition enterprise itself. Our emphasis in this section is on defense acquisition.

Acquisition Reform

The defense acquisition enterprise is unique; it operates with public funds, with primarily one buyer, little competition, contracts signed years in advance based on cost estimates, and decisions made in complex stages by multiple organizations. The process is infused with disparate goals and objectives: to have the highest performing technology at the lowest price possible in the fastest amount of time; to ensure the defense industry and related economies remain solvent; and to encourage small business, minority contractors, and women-owned businesses (Cancian, 1995). The number of participants in the acquisition enterprise is large, and each has different goals and measures of success. It seems that we cannot agree on what needs to be reformed—let alone how to fix it.

Historically, reforms have been enacted for primarily two reasons: increasing complexity of the technologies involved and individual corruption and abuse for monetary gain. Excesses in time and cost, or deficits in performance, are some of the more obvious outward signs that reform is warranted. It took 25 years from the time the Air Force identified the need for an advanced tactical fighter to replace the F-15 until the F-22 was combat-ready. During that time, defense spending cuts caused several major re-phasings of the program, adding to the delay.

The M247 Sergeant York DIVAD (Division Air Defense gun) was born of the Army's need for a replacement for the ageing M163 20mm Vulcan A/A gun and M48 Chaparral missile system. When the first production vehicles were delivered in late 1983, there were many performance deficits, most notably the radar’s inability to distinguish between a hovering helicopter and a clump of trees. This problem and others proved insurmountable and, in December 1986 (after about 50 vehicles had been produced), the entire program was terminated.

The list of acquisition regulations and initiatives is fairly lengthy but, as shown by Drezner et al. (1993), reform initiatives from 1960 to 1990 did not reduce cost growth on 197 defense programs. In fact, the average cost growth on these programs was 20% and did not change significantly for 30 years. Christensen et al. (1999) reaffirmed this conclusion and also found that initiatives based on the specific recommendations of the Packard Commission did not reduce the average cost overrun percent experienced on 269 completed defense acquisition contracts evaluated over an 8-year period (1988-1995). Actually, cost performance experienced on development contracts and on contracts managed by the Air Force worsened significantly.

These findings raise the question of whether it is possible to transform the acquisition enterprise, and to have the varied stakeholders agree to any extent that the process has actually improved. This question leads to the following brief review of the current state of acquisition research.

Acquisition Research

A quick review of recent acquisition research topics indicates a tendency to concentrate on single-issue concepts such as outsourcing, contractors, leasing, privatization, contingency contracting, performance measurement and financial management. Considering the 2004 and 2005 Annual Conferences on Acquisition Research, topics covered included:

- Acquisition avenues such as market-based acquisition, capabilities-based acquisition, competitive sourcing, and outsourcing
- Acquisition issues such as program management, performance management, and business process reengineering
- Financially oriented topics such as financial management, total cost of ownership, and real-option models

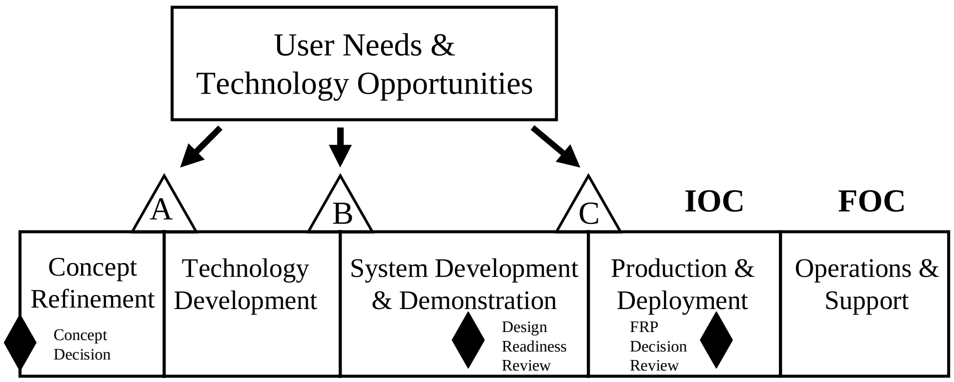
Further, acquisition policy in general was, of course, a recurring theme. While improving the performance and/or judging the effectiveness of each of these topics is worthwhile, it is also important to study the overall acquisition enterprise as an integrated and interactive complex system.

Currently, however, only extremely limited acquisition research is being conducted—primarily by internal DoD organizations, such as the Naval Postgraduate School, Defense Acquisition University, Air Force Institute of Technology, and DoD FFRDC's (e.g., RAND and LMI). Although these research projects offer valuable assessments of current practices and suggestions for improvements, the results are often limited in scope and may only address one specific problem at a time, often replicate previous or parallel work, and generally have limited general application. These efforts constitute only a fraction of the effort that is warranted by the size, complexity, and changing nature of DoD's acquisition challenges. They are not a substitute for disciplined, replicable academic research (Gansler, 2005).

Acquisition Lifecycle

Figure 1 depicts the Defense Acquisition Management Framework provided in the Defense Directive 5000.1 (DoD, 2003). This process provides both the context for transformation of acquisition and an opportunity, in itself, for transformation. In fact, the ways in which the many stakeholders in the acquisition enterprise exercise this process strongly affect the time, costs, and uncertainties associated with the acquisition of complex systems. In light of the Secretary of Defense's stated transformation priorities, this process would seem to be a good candidate for fundamental change.

Figure 1. Defense Acquisition Management Framework



THE ACQUISITION ENTERPRISE

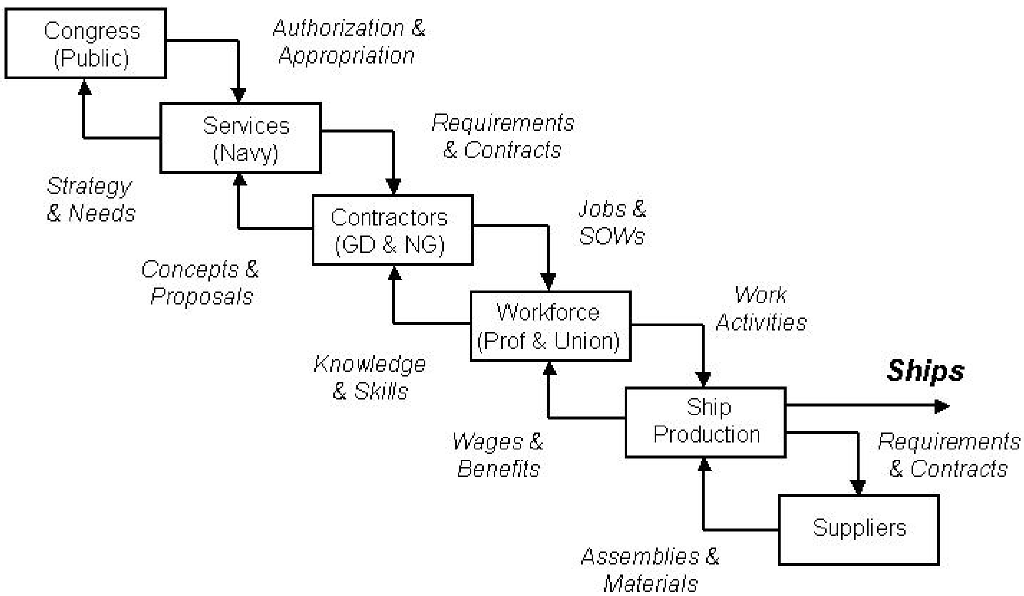
Consider the enterprise of military shipbuilding. This enterprise is facing serious cost challenges. Shipbuilding costs have increased enormously in the past three decades, far beyond inflation during this period. Consequently, customers for these ships anticipate buying fewer ships, which tends to exacerbate the cost challenges. This paper addresses the question of where resources should be invested to transform the enterprises such as shipbuilding and ameliorate these problems.

Enterprise Issues

As indicated in Figure 2, the enterprise of interest includes a set of stakeholders and issues much broader than those directly associated with the ships of interest. Congress, the services, defense contractors and workforce organizations have significant impact on the returns and risks associated with alternative investments. These stakeholders affect the ship building enterprise in a variety of ways:

- Congressional Interests & Mandates, e.g., Jobs & Other Economic Interests
- Service Interests & Oversights, e.g., Procedures, Documentation & Meetings
- Incentives & Rewards for Contractors, e.g., Cost-Plus vs. Firm Fixed-price
- Lack of Market-Based Competition, e.g., Hiring & Retention Problems
- Aging Workforce & Lack of Attraction of Jobs, e.g., Outsourcing Limitations, Underutilization of Capacity

Figure 2. The Overall Shipbuilding Enterprise



Military vs. Commercial Ships

There have, in recent years, been many studies of best commercial practices in manufacturing and assembly, e.g., Lean and Six Sigma, and attempts to adopt these practices for military shipbuilding. These initiatives have had positive impacts. However, there are important differences between military and commercial ships:

- Ship Size & Complexity—Slower Design
  - Commercial: Large & Relatively Simple
  - Military: Complex & Relatively Small
- Acquisition Process—Slower Buying
  - Commercial Simpler than Congressional/Military
- Design & Construction—Slower Production
  - Commercial: Large Steel Boxes with Simple Systems
  - Military: High Density of Integrated, Sophisticated Equipment
- Workforce Character—More Expensive People
  - Commercial: Mostly Blue-collar Workers

- Military: Much More Engineering Support

Consequently, commercial shipbuilding “best practices” are, in many respects, inapplicable to military shipbuilding, especially for naval combatant vessels. This is not to deny that some subset of commercial “best practices” can be transferred to military shipbuilding, but these are unlikely to dramatically reduce military shipbuilding costs.

PORTFOLIO MANAGEMENT APPROACH

We advocate a portfolio management approach to enable understanding and balancing the returns and risks associated with alternative investments, as well as highlighting investments that dominate alternatives in terms of both returns and risks. Figure 3 depicts a typical portfolio for a military weapon system.

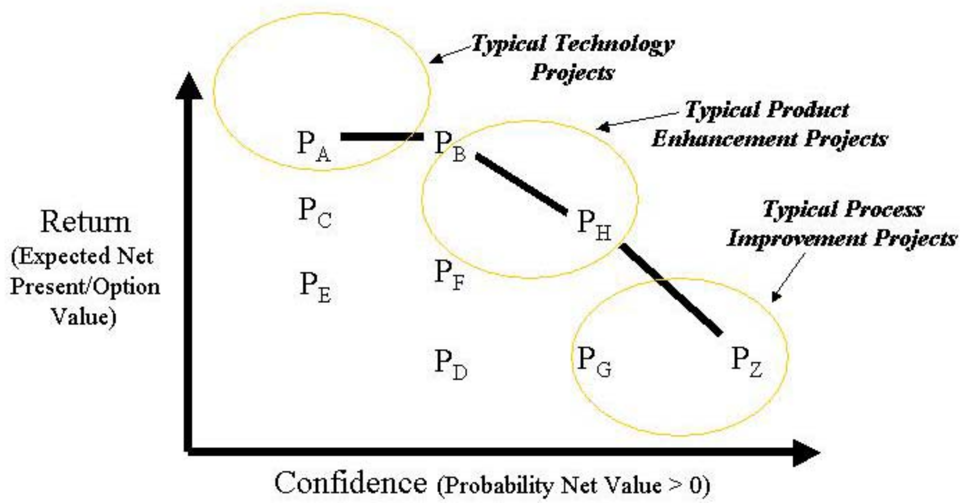


Figure 3. Example Portfolio Plot for Military Weapon System

Alternative investments, denoted by the Ps, are characterized in terms of return and risk. Return is expressed as either Net Present Value or Net Option Value, the latter being appropriate when investments are staged with intervening decision points for continued investment. Confidence (i.e., 1- Risk) is expressed in terms of the probability that Net Value exceeds some threshold, in this example zero.

The characterization of Confidence for each project enables consideration of the variability of Return for each investment. Thus, for example, P_D, P_G, and P_Z are equivalent in term of Return. If Return were the only metric, these potential investments would be equivalent. However, once Confidence is added, it is clear that P_Z is the superior investment.

Sources of Uncertainty

The importance of characterizing the variability of returns requires that we consider sources of uncertainty in the shipbuilding enterprise. Figure 4 provides an initial characterization of sources of uncertainty. Clearly, the various stakeholders outlined earlier have significant impacts on uncertainties in terms of both magnitudes and timing of returns. A portfolio management approach requires that we model these sources of uncertainty and use this model to derive a probability distribution for savings cash flow and net value to enable characterizing Confidence for each potential investment.

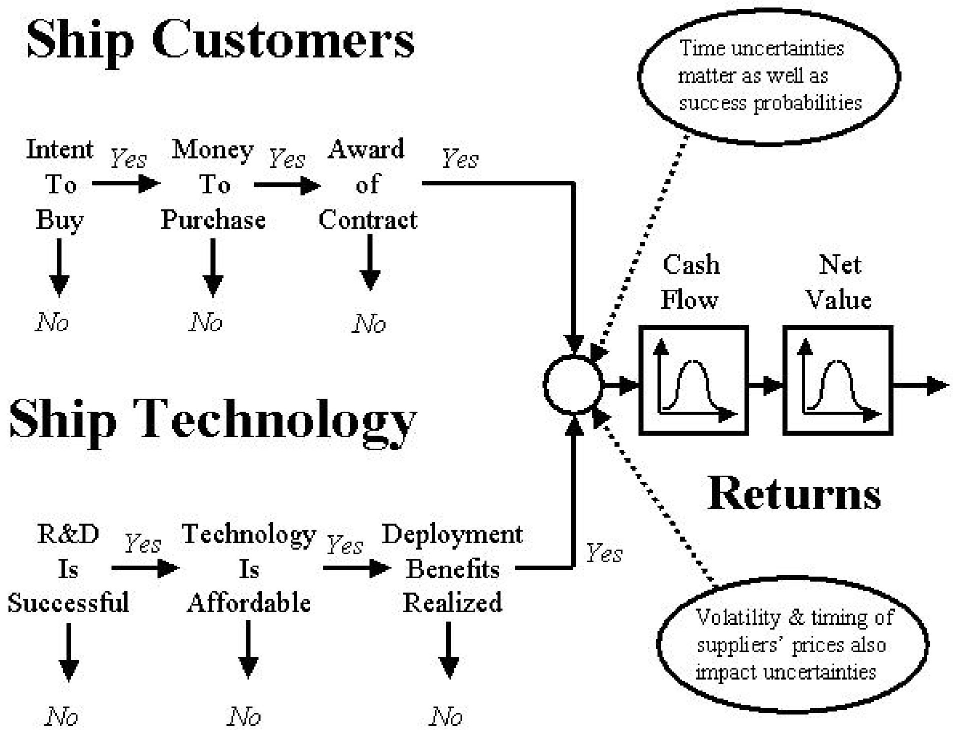


Figure 4. Sources of Uncertainty in Ship Building

Investment Valuation

When considering whether to invest in any initiative, the inevitable question arises, what is the value of that initiative? For a private-sector initiative, this question, at least in theory, has a relatively straightforward answer. The value of an initiative is the expected present value of the future cash flows. Since private firms seek to maximize their profits, such a single objective measure is not unreasonable.

The public sector is a little more complicated. Government agencies typically seek to balance multiple, competing objectives to maximize the public good. In an ideal world, one could establish a measure of public utility over the set of competing objectives, and the value of an initiative would be the utility it is expected to deliver. Since developing an explicit utility function for public good would be a highly political exercise, we will leave determining the public good to policy makers. Thus, we take the tact here that the goals of a government agency such as the DoD have been set, and the initiative we are concerned with are those that minimize the cost of achieving those goals.

Fixing the goals allows us to value monetarily what amount to process change initiatives. Given a current process for achieving a set of goals (e.g., the current DoD acquisition process in Figure 1), what savings would a process change yield? The expected present value of the cost savings would be the value of this process change. This transforms the value of a public-sector initiative into a series of cash flows and opens the door for us to use investment valuation tools developed for private-sector investments.

Traditional Approach. The traditional measure of the value of an investment is Net Present Value (NPV). NPV is simply future cash flows (positive or negative) discounted to present value and summed. If the NPV is positive, the investment is worth the cost. In a risk-free world, NPV would be a perfectly acceptable measure, but when uncertainty is introduced, NPV tends to undervalue investments.

There are two key reasons for undervaluation. The first is that an NPV valuation assumes total commitment to an investment regardless of intermediate results. If, for example, an R&D project is found to be technically infeasible shortly after it is begun, all of the planned expenditures will be made despite the new information that has been gained. Thus, NPV does not reflect managerial flexibility to terminate investments, which is of considerable value in limiting downside risk.

If managerial flexibility reduces downside risk, it stands to reason that failing to account for it undervalues a project. One way to compensate for this shortcoming of NPV is to employ a decision tree. A decision tree can be used to account for managerial flexibility, and it produces an expected NPV that is a better measure than the traditional, deterministic NPV. Decision trees, however, do not account for the second shortcoming of NPV, which is a little more subtle.

The question always arises when calculating NPV, what is the appropriate discount rate? Traditionally, the answer is the enterprise's cost of capital (i.e., the effective interest rate at which the enterprise can borrow money) because it reflects the rate of return that investors demand from the enterprise given its level of systematic (market) risk. The problem is that the riskiness of any particular investment may not be the same as that of the overall enterprise and will change as new information is gained over the course of the project. Since investors demand different rates of returns for different levels of risk, the discount rate will change as the project progresses. In theory, the appropriate discount rates can be derived from a capital asset pricing model, but in practice this is rather difficult.

Real Options. A real-options approach accounts for both managerial flexibility and appropriate risk-adjusted discount rates. A call option is the right, but not the obligation, to buy an asset (such as shares of stock) at a pre-specified price over a pre-specified time interval. One type of call option, known as the European call option, specifies a particular date on which the option can be exercised. When the date of expiration is reached, if the price of the underlying asset is greater than the pre-specified purchase price, the option holder would want to exercise the option since the asset is worth more than its price. If, on the other hand, the price of the asset were below the pre-specified price, the option holder would, obviously, not want to exercise the option. Thus, a call option mitigates downside risk since the most that can be lost is the purchase price of the call option.

Now, consider product development. Assume that there is an initial investment to develop the product, and then a subsequent investment required to build a factory to produce the product. This investment is analogous to a call option. The initial investment buys the business the option to build a factory to produce the new product. The underlying asset is the present value of the free cash flows generated from the sales of the product. Since market conditions change over time, the value of the market for the product will also change. At the end of the development phase, if management felt that it would lose money selling the new product, they would certainly not build the factory. If, on the other hand, the new product appears profitable, they will build the factory, i.e., exercise the option that they "bought" with their initial investment in product development (Rouse & Boff, 2004).

Black and Scholes (1973) in their seminal paper developed a closed-form equation that determines the fair price of a European call option; and subsequent researchers have developed methods to price many other types of options. The basic premise of their pricing scheme is that options draw their value from the behavior of the underlying asset. For real options, the underlying asset is the expected present value of the future cash flows that are generated from a successful implementation of an initiative. These cash flows would be subject to a variety of uncertainties, the nature of which depend on the particular domain of interest.

Now, consider process-oriented initiatives such as transformation of acquisition. For a large project, one would likely divide the project up into several stages to mitigate risk. As indicated in Figure 4, there are several kinds of risks of concern. We can, at least initially, group these uncertainties into two classes: market risk and technical risk. Market risk is the uncertainty in the final outcome of the project. For a process-change project, the savings achieved will be heavily dependent upon the prices or costs of the inputs to the process. As the prices of those inputs fluctuate, so will the value of the project. If, for example, the prices of several major inputs were to fall precipitously, it might make the effort involved to change the processes not seem worth it. Technical risk involves the uncertainty in the execution of the project. Budgets and priorities might shift, the requisite personnel might not be available, or the idea behind the process change simply might not work. Staging a project provides managerial flexibility and the ability to limit downside risk.

Each stage provides project management an option to discontinue the project. So, a multistage project could be viewed as a compound call option. The last stage is a call option on the future cash flows, but the stage before would be an option to buy the call option, and so on. It turns out that if we make certain assumptions about the variability of the underlying asset, there is analytic equation that determines the value of a compound call option (see Geske, 1979; Cassimon et al., 2004). Another approach that is more intuitive and flexible is the binomial lattice method (Luenberger, 1998; Trigeorgis, 1996).

<u>Example</u>. To illustrate how the real-options approach could be used to value a process-improvement project, assume that we are considering revising acquisition procedures for new weapon systems such that we reduce the cycle-time for early stage activities such as developing requirements and specifications. These are fairly manpower-intensive tasks, and, hence, we would assume that the savings from this procedural change would come as a reduction in the number of man-hours required to carry out these tasks. There are two things we need to determine: What is the value of these savings, and are the savings worth the cost of making the change? To use the real-options approach, we must first characterize the behavior of the underlying asset—in this case the present value of future savings.

For simplicity, let us assume that this is a three-stage initiative. The first stage involves studying the feasibility and implementation of the proposed reform. The second stage involves a pilot test of the revised process on an actual acquisition program, and the third stage involves implementing the new process DoD-wide. Each stage has an implementation cost, a probability of success, and an expected duration. We will assume the following notional values for the cost, probability of success, and duration of each stage. We also assume that since the government borrows at the risk-free rate, the cost of capital or discount rate is equal to the risk-free rate.

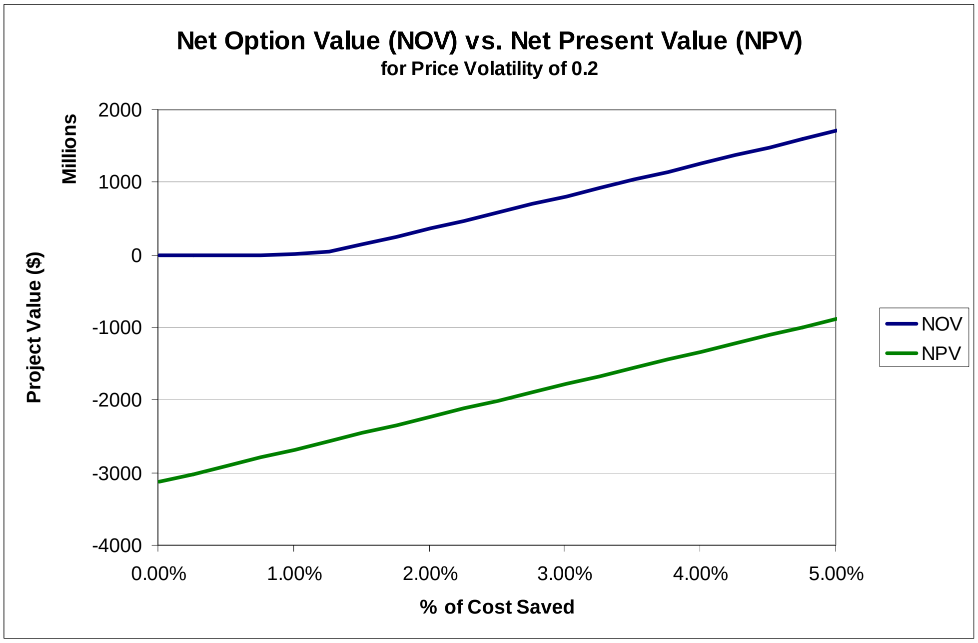
Table 1. Project Stage Parameters

Stage	Cost	P(Success)	Duration (years)
1	$ 1,000,000.00	0.3	0.5
2	$ 500,000,000.00	0.5	2
3	$ 3,000,000,000.00	0.75	N/A

Note that the duration of the final stage is not relevant for this analysis because we assume that the costs and benefits are discounted to the point of decision. Since no further decisions are made after the decision to enact stage three, we are not concerned with the stochastic behavior beyond that point.

Based on a representative set of model parameters, e.g., a savings rate of 2%, we obtain a traditional expected net present value of -$2,236,145,664—an expected loss of over $2 billion. However, this valuation does not account for managerial flexibility. When we evaluate the project as a real option using the binomial lattice method with a time step size of 0.01 years, we get a value of $355,852,308. Thus, the project actually has an expected gain of over $350 million. Of course, these results are for a particular rate of cost savings, i.e., 2%. As we vary the value of this parameter, we see in Figure 5 that the net option value (NOV) is always greater than the expected net present value (NPV).

Figure 5. NOV and NPV vs. Savings Rates



We see that for savings rates under about 1%, we would reject this project if we used NOV as our decision criterion. However, if we used NPV as the criterion, we would reject this project even for savings rates greater than 5%.

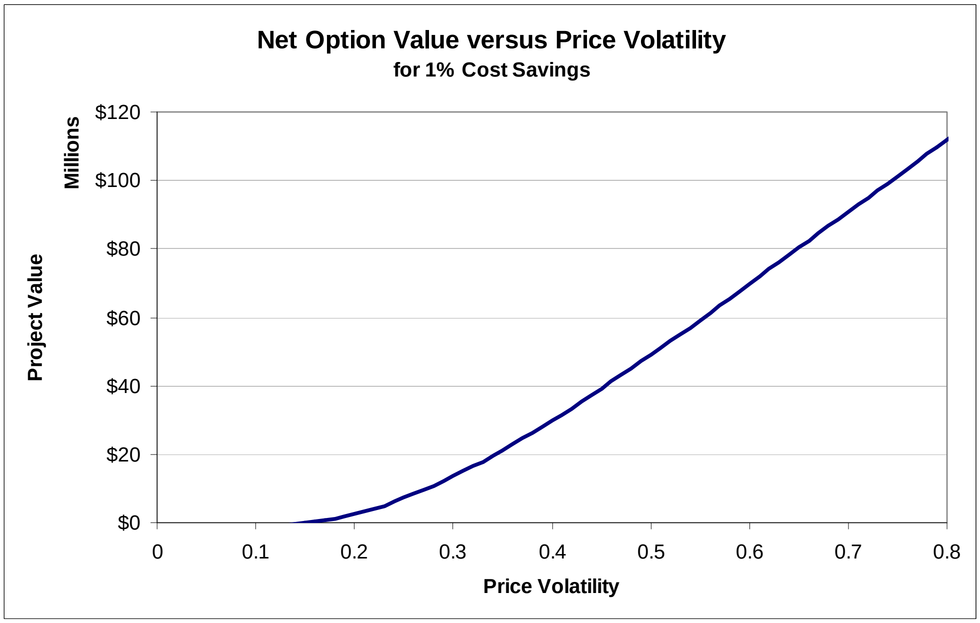
What about the uncertainties in the project outcome? It is a well-known property of options that they actually increase in value when the uncertainty increases. This is because managerial flexibility reduces downside risk while preserving upside potential. This is especially true for "borderline" projects. Figure 6 depicts the change in net option value as the log volatility of price-per-man-hour changes when the savings rate is set to 1%. Log-volatility is a measure of the uncertainty or noisiness of the price. We see that as it increases the value of the option increases.

This trend applies to technical risk as well as market risk. The real options methodology is consistent with the intuitive notion that one can undertake highly risky projects if one stages them to limit downside risk. This allows for justification of worthwhile projects that would have been rejected under a more traditional NPV analysis.

Often, one may have many such projects under consideration. If we assume that the projects are fairly independent, we would like to examine the risk-reward trade off of our portfolio. In theory, risk has been fully accounted for in the net-option value, and any other examination of risk would be a form of double counting. But the problem is that the option value calculation presumes risk neutrality on behalf of the decision makers with regard to any non-systematic (non-diversifiable) risk. The rationale behind this is that the shareholders of a firm also hold shares of many other firms, and they can diversify away any risks that are not intrinsic to the marketplace. If the managers of a firm truly serve the shareholders of a firm, then they should be risk-neutral with regard to any non-systematic risks (e.g., the failure of the project).

Of course, we know in reality that this is not really true. A manager's job may depend upon the success or failure of a project, and there may be shareholders who do not hold fully diversified portfolios (as in the case of the government). Thus, these entities are likely to be at least somewhat risk-averse. While risk neutrality is a convenient assumption for valuation purposes, it would be meaningful to a risk-averse decision maker to see some measure of the uncertainty in a project's outcome.

Figure 6. Sensitivity of NOV to Volatility in Price per Man-hour



There are several possible measures of risk with variance being the most common in a financial setting. In this case, however, we have used staging to mitigate much of the downside risk while preserving the upside risk. Since variance does not distinguish between the two, high variance in this case may actually be good. Nevertheless, most decision makers would like to know about the downside risks of a project. One possible measure of the downside risk of a project is the conditional expected value of a loss. That is, if the project does experience a loss, how big of a loss can be expected? Such a quantity can be somewhat cumbersome to determine with complicated projects, so Monte Carlo simulation was used to determine the conditional expected loss for the previous example.

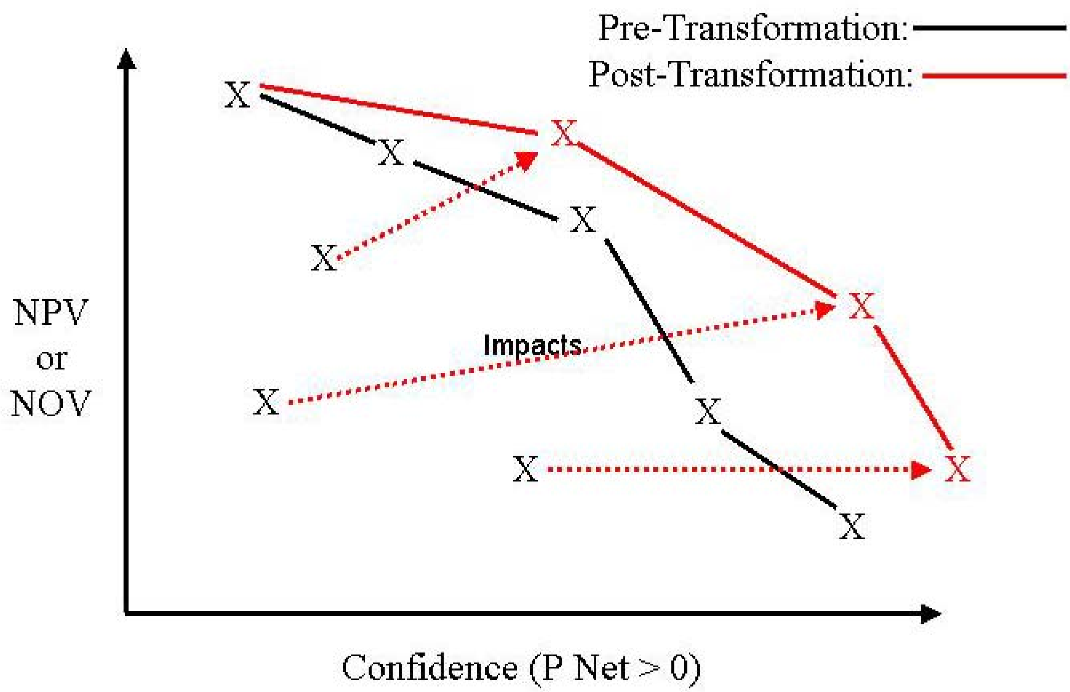
For the example project, the conditional expected loss was found to be approximately $330 million. That means that if there were a loss, on average it would be $330 million. Considering that the total implementation costs for the project are about $3.5 billion, we can see the power of staging as a risk-mitigating factor. If we had a portfolio of many such projects, we could plot their net option values versus their conditional expected losses to better understand the balance between risk and reward. The result would be a portfolio plot such as Figure 3—in this case using risk rather than confidence.

ENTERPRISE TRANSFORMATION

Enterprise transformation is driven by experienced and/or expected value deficiencies and is enabled by changes of work processes (Rouse, 2005a, 2005b, 2006). By "work," we mean any relevant activities pursued by any of the actors in Figure 2. Thus, changes might be affected in organizational processes for policy, authorization, appropriation, acquisition, development and deployment, or of technical processes for design, production, operations, maintenance, and repair. Work processes may be changed to increase returns and/or decrease risks.

In general, the type of changes just outlined will impact time, costs, and uncertainties. These impacts will, in turn, affect the timing and magnitude of expected cash flows and, hence, the NPV, NOV and Confidence associated with potential investments. A typical result, as shown in Figure 7, is that transformation affects the attractiveness of the potential investments depicted on the portfolio plot. In this example, the set of non-dominated alternatives has changed due to transformation initiatives that, in this instance, have somewhat increased return and substantially increased Confidence.

Figure 7. Characterizing Impacts of Enterprise Transformation



Thus, employing the methodology described in this paper, one can assess the economic value of alternative transformation initiatives. This is particularly important in the public sector where, in our experience, there is an abundance of transformation initiatives. Most of these initiatives make sense. However, it is difficult to choose those few initiatives deserving of major investment without some means of assessing the relative value of alternative initiatives. The methodology presented here provides such a means.

CONCLUSIONS

The acquisition of public-sector complex systems is time consuming, very expensive, and rife with uncertainties. Consequently, the enterprise associated with acquisition is an excellent candidate for transformation—fundamental changes of organizational processes for policy, authorization, appropriation, acquisition, development and deployment, or of technical processes for design, production, operations, maintenance, and repair. This paper has argued for an enterprise-wide perspective when choosing among alternative transformation initiatives.

We have also argued for economic valuation of the alternative transformation investments and presented an options-based methodology for such economic assessments. A notional example was used to illustrate the impact of this approach versus a more traditional approach. In general, traditional discounted cash flow methods very much under-value multi-stage initiatives. Options-based approaches, in contrast, enable many more early-stage investments but fewer later-stage investments, thereby not diluting resources to invest in high-payoff transformation initiatives.

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- USAF IT Commodity Council
- Contractors in 21st Century Combat Zone
- Joint Contingency Contracting
- Navy Contract Writing Guide
- Commodity Sourcing Strategies
- Past Performance in Source Selection
- USMC Contingency Contracting
- Transforming DoD Contract Closeout
- Model for Optimizing Contingency Contracting Planning and Execution

Financial Management

- PPPs and Government Financing
- Energy Saving Contracts/DoD Mobile Assets
- Capital Budgeting for DoD
- Financing DoD Budget via PPPs
- ROI of Information Warfare Systems
- Acquisitions via leasing: MPS case
- Special Termination Liability in MDAPs

Logistics Management

- R-TOC Aegis Microwave Power Tubes

- Privatization-NOSL/NAWCI
- Army LOG MOD
- PBL (4)
- Contractors Supporting Military Operations
- RFID (4)
- Strategic Sourcing
- ASDS Product Support Analysis
- Analysis of LAV Depot Maintenance
- Diffusion/Variability on Vendor Performance Evaluation
- Optimizing CIWS Life Cycle Support (LCS)

Program Management

- Building Collaborative Capacity
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to Aegis and SSDS
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Terminating Your Own Program
- Collaborative IT Tools Leveraging Competence

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